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Climate Class Adjustments Improve Accuracy of Predicted Fuel Moisture Stick Values

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In the National Fire-Danger Rating System (NFDRS), a correction is added to fuel moisture stick values to offset weathering effects. This correction is now being adjusted to compensate for different weathering rates in different climates. The corrections for NFDRS climate class 2 appear quite representative of actual fuel stick weight losses in the Southwest. This climate class adjustment improves fire-danger assessment.

Keywords: Fuel moisture stick, National Fire-Danger Rating System, climate class

Management Implications

A correction factor is added to fuel moisture stick readings to compensate for dry weight loss with age caused by weathering. Because recent evidence indicates that this correction is not valid for all climates, an untested, intuitive adjustment of this correction based on climate classes is now incorporated into AFFIRMS, the computerized fire-danger rating process. Results reported here show that this adjustment for stick aging in climate class 2 is quite accurate.

The 10-hour timelag fuel moisture is significant in the computation of NFDRS fire-danger indexes for many of the fuel models. Because the fuel stick age correction without climate class adjustment increases this fuel moisture value more than is actually occurring in drier climates, fire-danger is underestimated. The climate class adjustment leads to more precise fire-danger assessment, better presuppression preparation, and an improvement in judging conditions for prescribed burning programs.

Introduction

The use of fuel moisture indicator sticks is recommended and preferred in the 1978 National Fire-Danger Rating System (Deeming et al. 1977). Fuel sticks continuously exposed lose dry weight because of weathering. Weights of basswood moisture indicator slats were adjusted with age because of substantial weathering weight losses in the South (Nelson 1956). Jemison (1937) reported considerable weight loss of 2-inch and 1/2-inch ponderosa pine dowels over a 7-year exposure period. Greater weight losses occurred in unsheltered sticks than in sheltered sticks. Morris (1959) demonstrated that, for a given exposure time, fuel stick dry weight loss varied depending on exposure locations and the resulting climate differences. He concluded that differences in amount of exposure to dew probably produced the greatest weathering differences in the Pacific Northwest.

Haines and Frost (1978) documented the effects of weathering with age on fuel moisture stick values. They determined corrections for fuel stick readings, in distinct moisture ranges, for sticks of various ages. This is the age correction incorporated in the 1978 National Fire-Danger Rating System (NFDRS) and AFFIRMS, the computerized fire-danger rating process (Helfman et al. 1975).

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Haines and Frost (1978) suggested that their adjustments might be too great for dry climates and too small for very moist climates. Published reports (Morris 1959, Harrington 1982) and personal contacts with fuel stick users[2] strongly suggested that less stick weight loss occurs in drier climates than NFDRS predicts. To compensate for this, AFFIRMS incorporated an adjustment of the fuel stick age correction based on NFDRS climate classes as defined by Deeming et al. (1977). This results in a reduced weight loss adjustment for drier climates. This study compares actual fuel stick dry weight losses from climate class 2 in the Southwest with those estimated by the previously untested, NFDRS age-climate class algorithm.

Methods

Fuel moisture sticks are constructed to weigh 100.0 grams when ovendry so that percent moisture content can be directly determined. As a quality control check, the ovendry weights of 19 new fuel sticks were measured. These sticks were then placed in field locations for specific periods of time to determine exact weight loss due to exposure time.

In 1981 and 1982, 77 fuel moisture sticks (including the 19 discussed above) were collected from climate class 2 stations, in 11 southwestern national forests, following their field use. Eleven fuel sticks were eliminated from analysis because of damaged dowels or exposure time greater than 6 months. Length and time of year of exposure plus precipitation amounts during exposure were noted for each of the remaining 66 sticks. The sticks were then ovendried at 105° C until weight loss ceased. Weight loss was calculated assuming all fuel sticks weighed 100.0 grams when new. Regression analysis was performed on fuel stick weight loss with exposure time. In an attempt to explain more of the weight loss variation, precipitation amounts and season of the year were added to exposure time as independent variables in a stepwise multiple linear regression. A chi-square test was also performed to evaluate the accuracy of the NFDRS model for estimating the current fuel stick weight loss data (Freese 1960).

Results and Discussion

The following tabulation shows the ovendry weights of the 19 new fuel sticks checked for quality control:

Ovendry weight	Number of sticks
grams	
100.1	11
100.0	5
99.9	2
99.6	1

[2]*Personal communications with John Deeming, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.*

All but one of these sticks were, for all practical purposes, usable as a 100-gram base for direct evaluation of percent 10-hour timelag fuel moisture. Based on this limited test, quality control in fuel stick manufacture appears to be quite good.

Average fuel stick weight loss was 0.35 grams per month of exposure. This compares to a weight loss of 0.53 grams per month in Michigan (Haines and Frost 1978) and a range of 0.27 to 0.67 grams per month for various climates in Oregon (Morris 1959).

Figure 1 shows a plot of weight loss of the collected fuel sticks against length of exposure time. Both linear and logarithmic regressions were tested with the data and were found to be equally representative. The logarithmic form is preferred and appears in figure 1, because Jemison (1939), Nelson (1956), and Haines and Frost (1978) state directly, or give evidence, that fuel moisture sticks weather more rapidly at the beginning of the exposure period than later. The NFDRS fuel stick weight loss model is also logarithmic and is plotted in figure 1 after adjustment for climate class 2. The NFDRS assumes no significant weight loss for sticks exposed 1 month or less. The regression is fuel stick weight loss $= (\ln\ (2.5\ ((\text{age} - 1.0)^{1.5}) + 1.0))$ (climate class/4), where ln = natural log and age = months of stick exposure. Climate classes range from 1 = arid to 4 = wet (Deeming et al. 1977) so a fraction of the aging correction is used depending on the climate class. The full correction is used for climate class 4 (4/4), 3/4 correction for climate class 3, and so on. The weight loss is most rapid immediately after the first month and continues to decrease with increasing exposure time.

The logarithmic regression of the current data follows the NFDRS regression very closely throughout the range (fig. 1). The greatest difference in weight loss estimation occurs just after 1 month of exposure. In the chi-squared test of model accuracy, the NFDRS model estimates the current data within 0.4 gram at the 3% level and within 0.5 gram at the 1% level.

Using precipitation together with exposure time in a multiple linear regression resulted in the following:

$$Y = 0.29X + 0.03Z + 0.01,$$

where Y = fuel stick weight loss in grams, X = stick age in months, and Z = precipitation in inches. The coefficient of determination (r^2) was 0.82 and the standard error ($S_{y \cdot x}$) was 0.18, compared to $r^2 = 0.79$ and $S_{y \cdot x} = 0.19$ when stick age alone was the independent variable (fig. 1). Therefore, the precipitation variable appears to improve the estimation ability only slightly. Adding season of exposure to the muliple regression failed to reduce the unexplained variability of stick weight loss.

The NFDRS estimated fuel stick weight loss with climate class adjustment compared very well with actual weight losses of sticks from climate class 2. The value of this accurate estimate can be seen in comparison of fire danger indexes such as the energy release component (ERC) and burning index (BI) computed with and without the climate class adjustment (table 1).

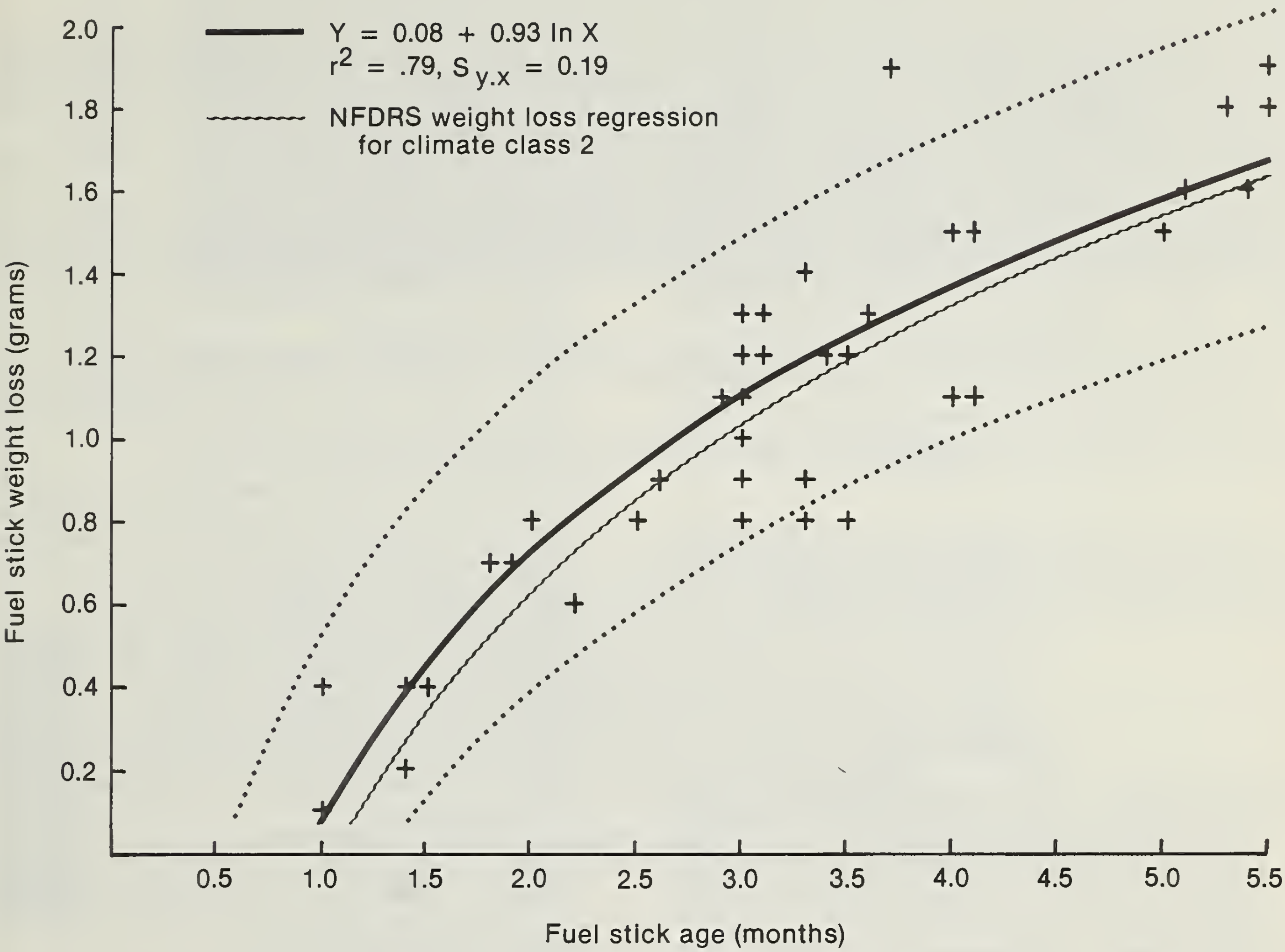

Figure 1.—A comparison of the actual fuel stick weight loss regression with 95% confidence bands to the NFDRS estimated weight loss regression for climate class 2.

Table 1.—A comparison of the energy release component and burning index with fuel stick weights uncorrected and corrected for climate class 2[1]

Fuel model	Energy release component		Burning index	
	Uncorrected	Corrected	Uncorrected	Corrected
U	30	33	49	51
J	182	192	187	192
B	30	41	64	98

[1]Indexes were computed using the TI-59 NFDRS program (Burgan 1979) and the following values: 1-hour timelag fuel moisture = 4, fuel stick moisture = 5, 100-hour timelag fuel moisture = 9, 1,000-hour timelag fuel moisture = 11, herbaceous moisture = 80, woody fuel moisture = 75, windspeed = 20 mph, slope class = 1, and fuel stick age = 5 months.

As Haines and Frost (1978) pointed out, the value of the correction depends upon the fuel model being used. Fuel models in which 10-hour timelag fuels are more prevalent will be affected more by the climate class adjustment. Table 1 shows that the closed timber model U is relatively unaffected by the adjustment. However, fire danger is influenced much more in the slash model J and brush model B. Therefore, because the climate class 2 fuel stick weathering adjustment is valid, its use in certain fuel types should improve the fire-danger assessment. Similar tests should be conducted in different climates to verify the other climate class adjustments.

The climate class adjustment is automatically performed by AFFIRMS. If fire-danger rating is calculated using the NFDRS handbook (Burgan et al. 1977) or using the TI-59[3] fire-danger program (Burgan 1979), this adjustment must be made manually.

[3]*The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.*

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